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Production Optimization for Two-Phase Flow in an Oil Reservoir

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Petroleum reservoirs are subsurface formations of porous rocks with hydrocarbons (oil and/or gas) trapped in the pores. Initially a reservoir may be under sufficient pressure to push the fluids to the surface. However, as the fluids are produced the pressure declines and production reduces over time. When natural drive becomes insufficient, then the pressure can be maintained artificially by injection of water. Conventional technologies for recovery leaves more than 50 % of the oil in the reservoir. Wells with adjustable downhole flow control devices coupled with modern control technology offer the potential to increase the oil recovery significantly.

The objective is to maximize production by manipulating the well rates and bottom hole pressures of injection and production wells. Optimal control settings of injection and production wells are computed by solution of a large scale constrained optimal control problem. We present a two-phase immiscible flow model and describe a gradient based method to compute the optimal control strategy. An explicit singly diagonally implicit Runge-Kutta (ESDIRK) method with adaptive stepsize control is used for computationally efficient solution of the model. The gradients are computed by the adjoint method. The adjoint equations associated with the ESDIRK method are solved by integrating backwards in time. The necessary information for the adjoint computation is calculated and stored during the forward solution of the model. The backward adjoint computation then only requires the assembly of this information to compute the gradients.

We demonstrate the optimal control strategy on a simple waterflooding example using one injector and one producer, which are divided into several individually controllable inflow valves.

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